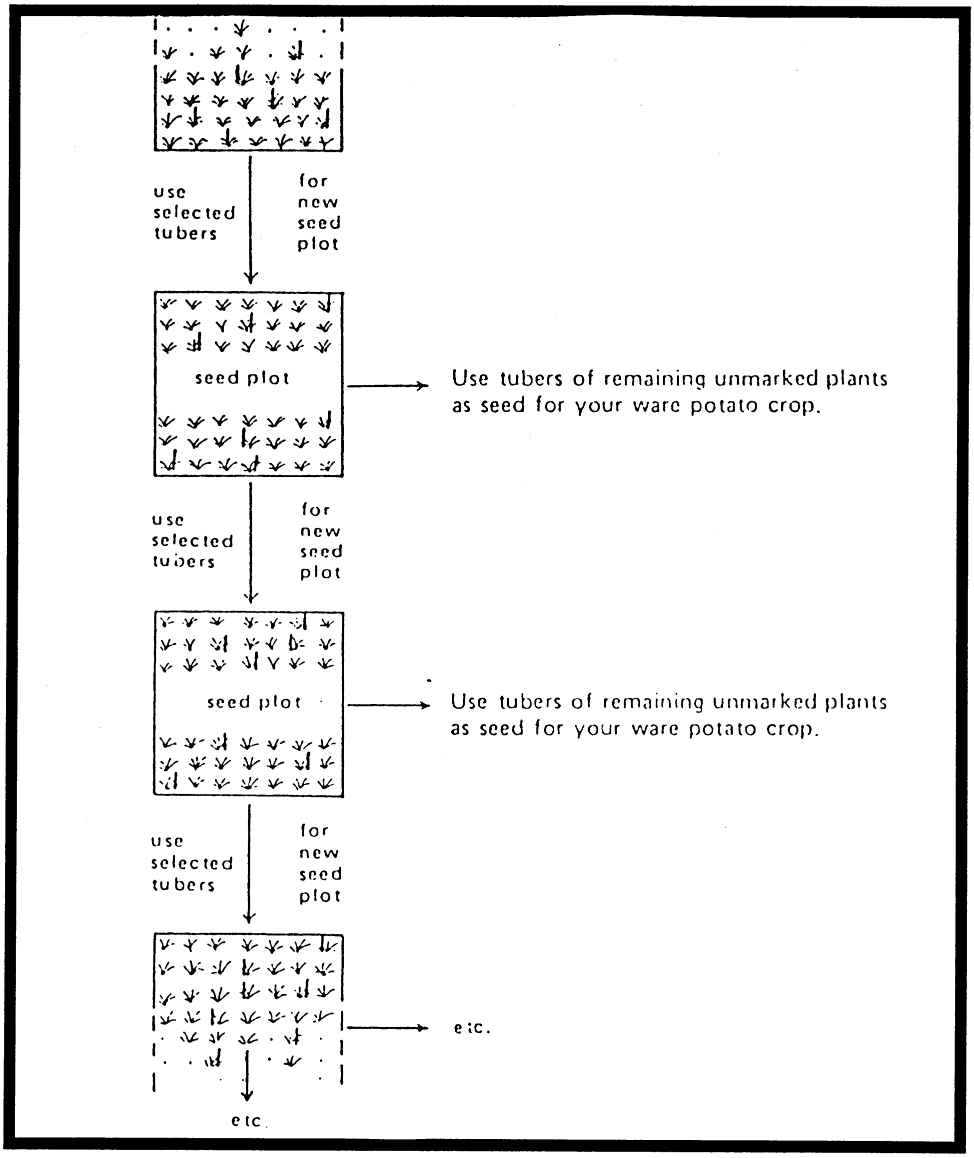
e) Store seed tubers harvested from staked plants <u>separately</u> from other potatoes to avoid mixture and contamination.

f) Plant the selected tubers the following year in a newly established seed plot, preferably on land not used for potatoes the previous season and, if possible, some distance from other potato crops.



Seed plot technique repeated each season.
(From Bryan, J.E., 1981, *On-farm seed improvement by potato seed plot technique*. Technical Information Bulletin 7 (TIB), International Potato Center, Lima, Peru.)

g) Again, as in (b), the best plants in the seed plot are staked.

h) The selected plants are harvested and stored as in (d) and (e). These tubers are needed to plant the seed plot the following season. Tubers from the remaining unmarked plants are multiplied to provide seed tubers for the farmer's own commercial potato crop during the next year.

i) The farmer should continue this process to ensure a marked and continuing improvement in the quality of his seed tuber material, in the health standard of his commercial potato crop, and in yields.

Calculation of the number of plants to stake to provide seed for one jerib.

A spacing of 65 cm x 25 cm = 61,538 plants/hectare
= 12,308 plants/jerib.

If the farmer gets 20 t/ha (4 t/jerib), the average yield per plant is 325 g. A healthy-looking and vigorous plant should give at least 450 g.

If 20% is lost during selection and storage, each plant provides 360 g or 12 seed pieces of 30 g each.

110 staked plants will provide 110 x 12 = 1,320 seed pieces for planting the seed plot in the following year.

110 plants will be staked for the next seed plot leaving 1,320 - 110 = 1,210 plants.

The tubers from these plants will provide 1,210 x 12 = 14,520 seed pieces, enough to plant a little more than one jerib.

If the farmer plants seed pieces larger than 30 g, he will have to stake more plants. For example, if the seed piece weight is about 40 g, stake about 150 plants. Similarly, if his yields are lower, he will have to increase the number of staked plants (e.g., twice the number if the yield is only 10t/ha, 2 t/jerib). In practice, make the seed plot slightly larger than calculated to compensate for plants eliminated at harvest or to allow for losses during storage. After one or two seasons, a farmer will know how many plants he has to stake so as to provide planting material for his commercial crop.

2.3 Selecting New Varieties

In many countries that had their own local varieties (usually old European varieties), newly introduced modern European varieties have outperformed and replaced them. Local varieties that farmers keep for decades become degenerate and yield levels fall. This problem exists in Afghanistan, and in Hunza, Pakistan. During the past two years in Hunza, the Dutch variety **Diamant** has yielded 40-60 t/ha, (8-12 t/jerib) double that of the local varieties, and farmers have begun to grow it. The same could happen in Afghanistan. A strategy for improving farmers' seed stocks could be through the introduction of a new variety that yields better than *Garma* and *Sarda*, keeps well under local storage conditions, and is acceptable to consumers. (Appendixes I and II).

White-skinned varieties that are grown extensively by farmers in Pakistan include **Diamant**, *Patrones*, *Ajax*, and *Multa*. In the first instance, it is better to try **Diamant**, which has a short dormancy and a harder skin than the other varieties and therefore stores better in pits. *Multa* is more difficult to store in pits, *Patrones* store very poorly, and *Ajax* is very susceptible to late blight.

Because the farmers' own seed potatoes and the **Diamant** seed tubers have been grown under different environmental conditions and storage has been different, the physiological ages of the materials will not be the same. This will have an effect on the yield potential, and therefore, the first season of testing is not the best comparison of the two varieties. A truer picture of **Diamant**'s performance will be seen in 1993 after it has been kept by farmers in pit stores throughout the winter. Valuable information on its post-harvest performance and storability under local conditions will be gained.

It is best to start with testing only one variety that we know will fit into the agro-ecological zones of Afghanistan. However, we cannot know if it will be accepted, without reservation, by farmers and consumers. Farmers' acceptance of the newly introduced variety can be measured by their willingness to continue to grow it and replace part or all of their existing potato stock of the traditional varieties. None of the harvest should be sold, and it will not be possible to get a measure of the market response to **Diamant**. The farm family must be asked to cook some of the potatoes to find out if they are acceptable from the flesh color and palatability standpoint.

2.4 Improved Cultural Practices

The highland crop, in such provinces as Kabul, Bamiyan, Ghazni, Logar, Paktika and Wardak is mostly grown in a three course rotation with wheat and clover. The clover is plowed in during land preparation in April, and the crop is planted from the end of April to the middle of May and harvested in September/October. Winter wheat is then planted and followed by clover after harvest from mid-July to the end of August.

In the low elevation potato-growing areas in Baghlan, Nangarhar and Kandahar where there are two growing seasons, the potato crop is planted in February/March and harvested during May and June.

In the major production provinces--Bamiyan, Kabul, Wardak, Ghazni, Logar, Paktika, and Baghlan--farmers who grew potatoes as a cash crop pre-war, up to the late 1970s, applied DAP and urea fertilizers as well as using farmyard manure. Farmers, who grew only a small area of the crop for their own use, did not apply artificial fertilizer. At present, the lack of availability of fertilizer is a main factor for low yields. If fertilizers were available in the market, farmers would apply them to the crop because they already know the financial benefits.

Changing cultural practices is the most difficult aspect of improving crop yields and has to be approached on a step by step basis. Farmers will not adopt a "package of practices", but are likely to change only one, or two at the most, production techniques (Appendix I). Therefore, it is important to target the issue of stem density that is greatly influenced by the size of the seed tuber or the cut seed piece and its physiological condition at planting. The size of the planting material itself influences the number of eyes, and therefore the number of stems. The physiological condition of the tuber also determines the rapidity of emergence. A stem density in the region of 20 stems per m^2 is desirable under good soil fertility. The extension agents should pay attention to this particular aspect and assist farmers in ensuring that this level is achieved. Poor soil fertility cannot sustain crops of high stem density because of the competition for limited amounts of nutrients.

2.5 Improved Storage

Traditionally, farmers in the highland areas where there is heavy snowfall and very low temperatures store potatoes throughout the winter in pits in the ground. As in other parts of the world, this is the only method available to small, resource-poor farmers.

At harvest, farmers market 50 percent or more of their produce. The rest is stored in pits either for seed for the following crop or for sale for consumption in the spring. Potatoes that they want to use for the family are stored in their houses.

Pits are simple holes dug in the ground, usually to a depth of at least 1 m, and are large enough to contain from one to six tons. (One ton of tubers occupies a volume of 1.5 m^3). In cross section, pits are either round, square or rectangular. The tubers are placed in the bottom of the pit to a depth of no more than 50 cm and then covered with soil. Some farmers may put a few inches of straw on the top of the potatoes before the covering of soil, but this is not a common practice. At ground level the soil is shaped like a mound to help run-off of water and lessen the chances of seepage into the pit.

Ventilation in stores is needed to remove heat, water and carbon dioxide, and to supply oxygen. Natural or forced draught ventilation can be used to ensure that air passes over the tuber surfaces. Natural ventilation of pit stores that are completely closed is not possible, and overheating occurs. This results in heavy losses due to rotting.

Progressive farmers in Bamiyan and Wardak Provinces incorporate chimneys into their pit stores to allow the hot air to escape, but air movement is restricted. The chimneys are made of wood, are 10 to 15 cm in diameter and extend up to 50 cm above the soil covering the pit. It is not known if use is made of the 10-cm diameter metal chimneys that are used in houses for heating stoves; these would be perfectly adequate.

In Wardak, some farmers leave an air space above the potatoes, place wood at ground level and then cover with soil. With this system, the movement of air is completely passive, and relies on the principle that hot air rises.

In Bamiyan, farmers dig pits 1-1.5 m wide and 10 m long. A wooden door is placed at one end and steps cut into the ground to get down to the base-level of the pit. The potatoes are placed in the bottom of the pit and covered with soil, as previously described, and three chimneys are fitted at regular intervals along the length of the pit. The space outside the pit, where the steps cut into the ground, is covered with wood. When the outside air temperature is not too cold, the covering is removed to allow air to pass into the pit via the door. This method allows through ventilation and reduces losses. Losses are greatest at the end of the pit furthest from the door because the air cannot circulate completely throughout the bottom layers of the potatoes. The construction could be improved by placing the tubers on a raised, slatted-wooden floor to allow free circulation of air through the entire pit. This idea should be tried with some farmers in Bamiyan and if proven, demonstrated in other major potato-growing areas.

III. INFORMATION FOR GROWING POTATOES

(Extensive use was made of the International Potato Center's Technical Information Bulletins (TIB), from which the diagrams are also taken, and Introduction to Potato Production by H.P. Beukema and D.E. Van der Zaag)

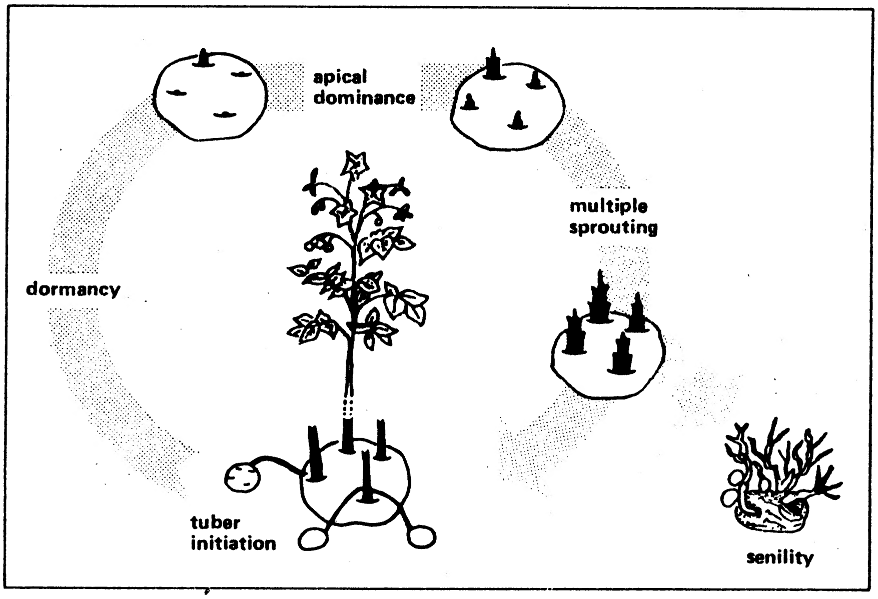
3.1 Potato Seed Tuber Physiology

After initiation, a potato tuber continually develops both morphologically and physiologically. The physiological age of a tuber refers, primarily, to the process of sprout development. It depends on the chronological age of the tuber as well as the environmental conditions.

During its physiological development, the potato tuber passes through the stages of dormancy, apical dominance, multiple sprouting, and senility. During this development, it changes from being physiologically *young* into being physiologically *old.*

The physiological age of tubers can be managed by growing and storage conditions. At harvest, tubers produced in a hot climate, in light structured soil, under low soil moisture and low nitrogen fertility conditions are physiologically older than those produced in a cool climate, in heavy soil with soil moisture and high nitrogen fertility.

TIB 20: Physiological Development of Potato Seed Tubers.



A crop grown from physiologically young seed tubers has a longer growing period and the total yield is higher than one grown from physiologically old seed tubers. Plants from physiologically old seed tubers develop their yield potential quickly.

3.1.1 Dormancy

Dormancy is characterized by no sprout growth. The tuber can remain dormant for several months, and no measurable sprout growth occurs even when conditions are ideal (15^0-20^0C and relative humidity about 90%).

The total dormant period is from tuber initiation until sprouting, but this is very difficult to determine. Post-harvest dormancy, i.e., from harvest to sprouting, is commonly used for practical purposes.

Factors affecting the length of dormancy are:

- Variety
- Previous growing season
- Storage temperature
- Tuber injury
- Degree of tuber maturity at harvest

Variety

Dormancy may last for less than one month to several months depending on the variety. The length of the dormancy period is not related to the length of the growing period of the variety.

Growing Conditions

The conditions under which the tubers are produced influence the length of the dormancy. For example, high temperatures, low soil moisture and low soil fertility during tuber growth (bulking) accelerate physiological development and reduce the dormant period.

Storage Temperature

High storage temperatures accelerate the physiological aging processes within the tuber, thus reducing the dormant period. In some varieties, a fluctuating temperature or a "cold shock" (below 10^0C) for 2-4 weeks is more effective in shortening the dormancy period.

Tuber Injury

Injuries caused by harvest and handling procedures, or by pests and diseases, reduce the dormant period. Cutting seed tubers also results in earlier sprouting.

Tuber Maturity

Immature tubers have a longer post-harvest dormancy period than tubers harvested at maturity.

3.1.2 Apical Dominance

At the end of the dormant period, buds in the eyes begin to grow and form sprouts. Frequently, the apical eye begins to sprout first, marking the beginning of apical dominance. The duration of this stage in the physiological cycle differs considerably among varieties. Planting seed with apical dominance often results in plants with single stems and this leads to reduced yields.

Apical dominance can be influenced by:

- o Storage management
- o De-sprouting

Storage Management

To promote sprout number, maintain a low temperature until apical dominance is over and then increase the temperature. To limit sprout number, maintain a high storage temperature (15^0-20^0C).

De-sprouting

Removing the apical sprout induces the formation of multiple sprouts, thus contributing to a uniformly sprouted tuber that produces several stems. Apical sprouts should be removed when they are still young. De-sprouting when the sprouts are old may cause damage, dehydration and poor de-sprouting.

3.1.3 Multiple Sprouting

After the apical dominance stage, additional sprouts develop and the multiple sprouting stage begins. Depending on the variety, this stage may last for several months, especially when the storage temperature is low. Diffused light helps to prolong the multiple sprouting stage and keep sprouts green, short and strong. This is the optimum stage to plant seed tubers. Tubers in this stage give rise to plants with many stems.

3.1.4 Senility

Senility is characterized by several symptoms:

- excessive branching of the sprouts
- production of long, weak sprouts
- production of small tubers directly on the sprouts

3.2 Cutting Potato Seed Tubers

In many countries, seed cutting is done, especially if the seed tuber size is large. This is done to:

- o Save seed and improve the multiplication rate
- o Increase the number of stems per seed tuber
- o Stimulate sprout growth

3.2.1 Method of Cutting

A sharp knife must be used for cutting so as to damage the minimum number of cells.

There are more eyes at the rose end than at the heel (stem) end at which the tuber is connected to the stolon. Therefore, when cutting a tuber into two pieces, the cut should be from the rose to heel end so as to distribute the eyes evenly between the two halves. Cuts should be made so as to distribute the eyes as evenly as possible, with a minimum of two to three eyes per piece.

3.2.2 Wound Healing

By promoting healing of the cut surface, seed piece decay can be prevented. After cutting, the superficial cells suberize and wound periderm is formed beneath the suberized layer. The time needed for the formation of the periderm layer depends on:

- Variety
- Age of tubers
- Temperature
- Humidity
- Oxygen content of the atmosphere

Wound healing is normally complete in three to five days in a moist atmosphere (cover trays or baskets of cut seed tuber with damp sacks) with sufficient oxygen and a temperature of approximately 15^0C.

Treating the cut surface with a fungicide dust containing at least 15% carbamate (e.g. Dithane M-45) may also help to reduce seed piece decay. Finely ground rice hull, ash, kaolin or talcum can be used as a filler (approximately four parts filler to one part fungicide).

If conditions at planting are favorable (moist soil, temperature 10^0-18^0C), cutting can be done immediately before planting; the cut surface should then heal quickly enough in the ground. At planting the seed piece should be placed with the cut surface downward.

3.2.3 Implications of Cutting Seed Tubers

By comparing the productivity of cut seed tuber pieces and whole tubers of the same weight, it is usually found that whole seed tubers give better yield. A whole seed tuber has more skin surface than a cut seed piece and consequently, can produce more stems.

If seed tubers are dormant or in the apical dominance stage, cutting may lead to earlier emergence and development of more stems per seed tuber. In this case the use of cut seed pieces can give better results when the same weight of tubers is planted per square meter.

Normally the percentage emergence is lower if cut seed tubers are used, because of "seed piece decay". In general, the percentage emergence is inversely proportional to the size of the cut seed pieces. Another disadvantage of cutting is

I. THE PRESENT SITUATION

1.1 Production Trends

During the past three decades potato has become an established vegetable crop in Afghanistan. Official Afghan Government statistics for the late-1970s showed that nearly 20,000 hectares (ha) were under cultivation (Table 1.).

Table 1. Potato production, 1975-78.

Season	Area ('000 ha)	Production ('000 t)	Yield (t/ha)
1975-76	17	194.5	11.4
1976-77	19.8	354.0	17.9
1977-78	19	200.0	10.5

The total production in 1976-77 appears abnormally high and cannot be explained. Annual production of about 200,000 tons (t) in 1977-78 is more realistic. Food and Agricultural Organization (FAO) estimates of production of over 300,000 (t) in the mid-1980s are questionable.

No data are available on current production which must have been drastically reduced since the civil strife began. In 1987, it was estimated that about 30% of farmland was out of production, and this could be reduced since then.

Sample surveys of farmers from provinces throughout Afghanistan, published in the reports of the Agricultural Survey of Afghanistan by the Swedish Committee for Afghanistan, (SCA) Peshawar, show that more than twice the number of farmers grew potatoes in 1989 than in 1988 (Table 2.). However, this increase was not maintained in 1990. Unfortunately, no comparable pre-1980 data are available.

The average potato area grown by each farmer in Bamiyan, Logar, Wardak and Ghazni was about 2 jeribs, and was only exceeded in Baghlan where the average was 4 jeribs. Farmers in many other provinces grew potatoes but the percentages were very low. Fluctuations in yields could be due to sampling error, but such factors as the availability of fertilizers cannot be discounted. Yields can be improved from the national average of 10.5 to 20 - 25 tons/hectare with the use of fertilizer, improved seed and improved management practices.

the transmission of diseases with the knife, e.g., potato viruses S, X, and Y, ring rot (*Corynebacterium sepedonicum*), black leg (*Erwinia* spp.) and bacterial wilt (*Pseudomonas solanacearum*). Transmission of these diseases can be partly remedied by disinfecting the knife between cutting different tubers.

Cutting should never be done if no great benefit is expected. When soil conditions are unfavorable (e.g., dry, wet, hot, very cold) or the seed is physiologically old, cutting should never be practiced.

3.3 Planting Potatoes

Farmers should realize that once potatoes have been planted the yield is already largely determined. The factors having a major effect on yield are:

- Seed bed (soil) preparation
- Planting procedure
- Planting depth
- Condition of the seed tuber--both health-wise and physiologically
- Seed rate--seed tuber/piece size and planting distance
- Fertilizer rate
- Ridging and weed control

After crop emergence, the three most important factors influencing yield are second earthing-up, water management and disease and pest control.

3.3.1 Seed Bed Preparation

Seed tubers should be planted in fairly moist, loose soil. If it is too loose or cloddy, it will dry out too easily. There should be no compacted layers under the seed bed that cannot be penetrated by the weak root system of the potato plant; deep rooting is important for good water supply to the crop.

A good seed bed ensures sufficient:

- oxygen for the underground parts of the plant,
- moisture retention, and
- drainage of water,

and leads to good growth of the roots and stolons and production of well-formed tubers.

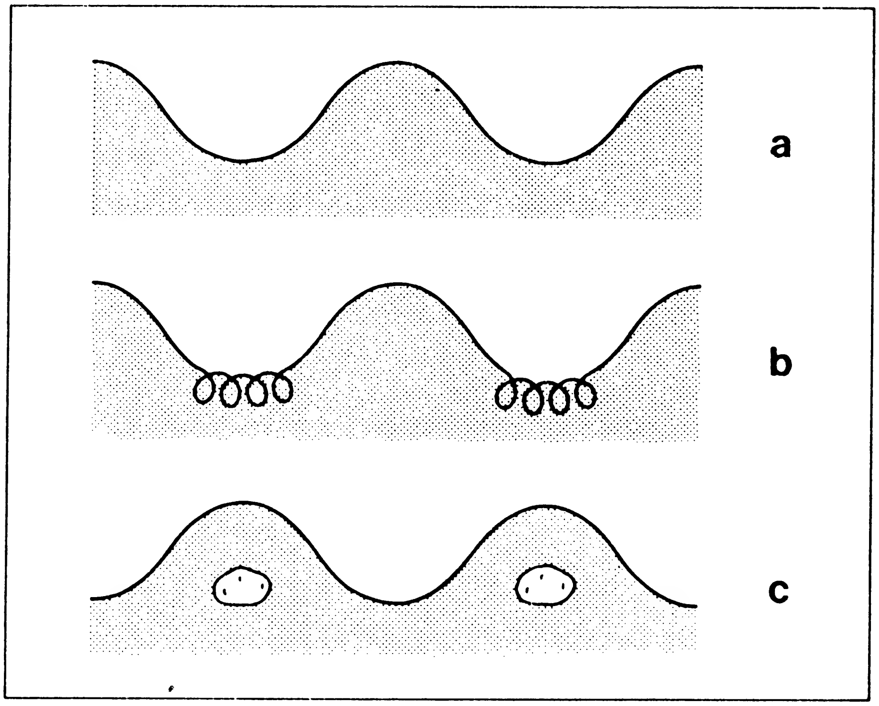
3.3.2 Planting Procedure

Planting should meet the following requirements:

- Seed tubers should be placed in moist, but not wet, soil that will not dry out before the tubers are covered.

Planting in Furrows

TIB 11: Planting Potatoes



Planting in furrows: form the furrows (a), mix the fertilizer with soil (b), plant the seed tubers and cover them (c).

- Seed tubers should lie at an even and correct depth and fairly accurately spaced in the row.

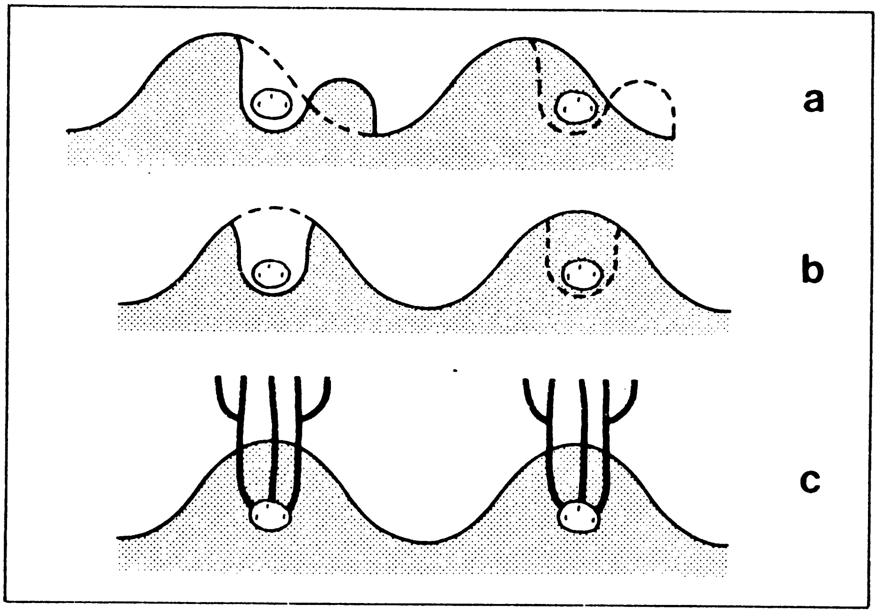
- Seed tubers should not be in direct contact with fertilizers.

- Sprouts of pre-sprouted tubers should not be damaged.

Planting by hand can be as good as or even better than planting by machine. Tubers can be planted in either furrows or ridges.

Planting in Single Ridges is done by opening auxiliary furrows or individual holes.

TIB 11: Planting Potatoes.



Planting in ridges: plant the seed tubers on the side (a) or at the center (b) of the ridges by opening auxiliary furrows or individual holes. Ridges after hilling (c).

Planting on Double Ridges is practiced by many farmers.

3.3.3 Planting Depth

Adjust the planting depth to the more important factor, either soil moisture or soil temperature.

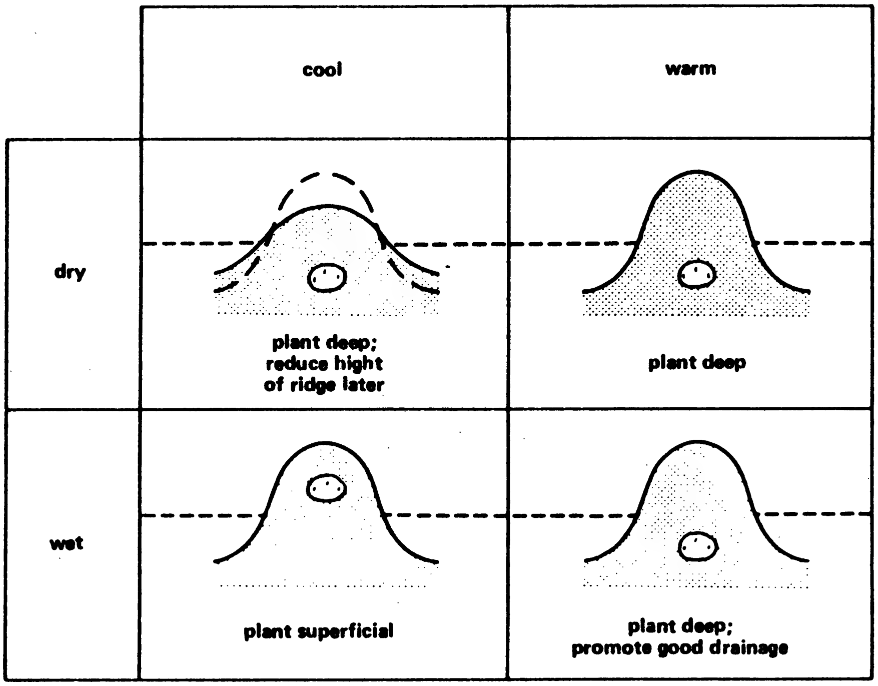
Adjustment for soil moisture. When the soil is dry, plant deep. When the soil is wet, plant shallow.

Adjustment for soil temperature. During the day the soil is warmer at the surface. When the soil is warm, plant deep. When the soil is cool, plant shallow.

Deep planting also protects the tubers from diseases and pests such as late blight and potato tuber moth, and prevents tuber greening when tubers are exposed to the light.

Superficial planting, while making the tubers more accessible to pests and diseases and increasing the chance of greening, does facilitate harvesting. A prerequisite for shallow planting is that there will be moist soil around the seed tuber and the necessary conditions for making a well-shaped, high ridge after planting.

TIB 11: Planting Potatoes.



Adjust the planting depth to the most important factor, soil moisture or soil temperature.

Large tubers are more adaptable to deeper planting than small tubers. Shallow planting of small tubers and seed pieces followed by high ridging may be a good way to regulate planting depth.

3.3.4 Planting Distance

Planting distance depends on variety, growing conditions and desired tuber size at harvest. If soil fertility or moisture is low, the soil can maintain fewer plants. The higher the crop density, the smaller will be the size of the harvested tubers.

The distance between rows depends on local practice, available implements and growth habit of the variety.

A wide distance between rows:

- provides more soil for ridging,
- prevents damage to roots, stolons and tubers during cultivation, and
- facilitates roguing in seed crops.

A narrow distance between rows:

- ensures that irrigation water reaches all roots, and
- increases efficiency in the use of land, nutrients (fertilizer), water and light.

3.3.5 Importance of Correct Planting

Correct planting ensures:

- rapid emergence, and
- uniformity of the crop.

Rapid emergence reduces the time that sprouts are exposed to danger from soil pests and diseases. The decay of seed tubers, and especially cut seed pieces, is reduced.

Crop uniformity is important for ensuring even ground cover (maximizing light utilization, reducing soil and water loss, weed control, etc.) and making cultivation practices (ridging, irrigation, spraying and harvesting) easier.

Both rapid emergence and crop uniformity are greatly influenced by the physiological condition of the seed tubers at planting.

3.3.6 Ridging Potatoes

Ridging should not be done until the potato plants have emerged. The ridging process is best accomplished in two or more steps. This process is done at first for weed control and secondly to provide adequate cover for the new forming tubers. Early ridging also helps maintain stable soil temperatures and prevent moisture losses. A large hill prevents attack by some insects, tuber greening, blight attack and high tuber temperatures.

The shallower the seed has been planted, the bigger the ridge should be. Since tuber growth may start as early as two to four weeks after emergence, the first ridging should not be delayed too long. If there is a possibility for leaching losses, nitrogen can be split-applied at planting and ridging. When nitrogen applications are split, the second application should not be later than three weeks after emergence.

3.4 The Effect of Stem Density on Potato Production

3.4.1 Definition

The density of a potato crop is traditionally expressed as the number of plants per unit area. However, a potato plant commonly consists of more than one stem. Each stem forms its own roots, stolons and tubers, and behaves like an independent plant. Consequently, stem density is made up of two components:

plant density x number of stems per plant.

Stem density describes the density of the potato crop better than plant density.

Stem density is commonly defined as:

main stems per square meter,

but lateral stems produced in the soil also form roots, stolons and tubers. Therefore, stem density is better defined as:

above ground stems per square meter.

Good ridging is important to ensure that lateral stems formed near the mother tuber are well covered with soil to promote root and stolon formation.

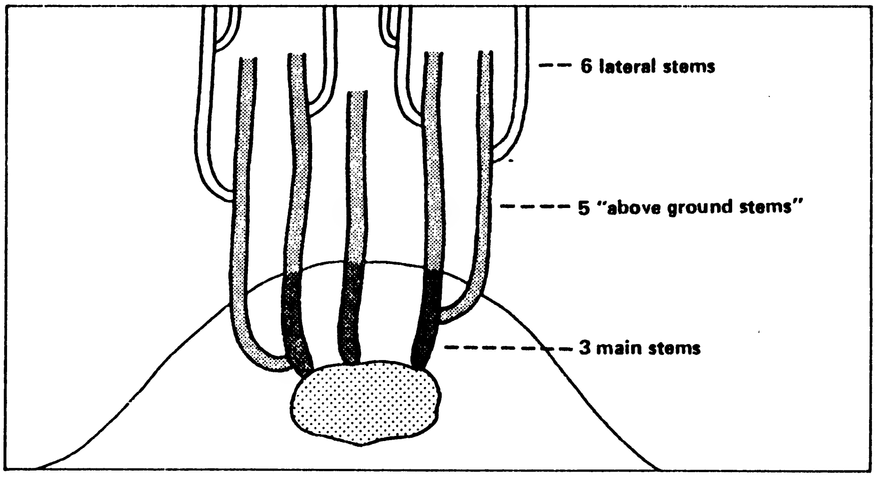
3.4.2 Effects of Stem Density

Stem density influences:

- Number of tubers
- Size of tubers
- Multiplication rate

The number and size of tubers influences yield.

TIB 1: Effect of Stem Density on Potato Production.



Main stems together with lateral stems branching from main stems below the soil surface are referred to as *above-ground stems*. A potato plant may consist of 3 main stems, 5 productive above-ground stems, plus 6 less productive lateral stems.

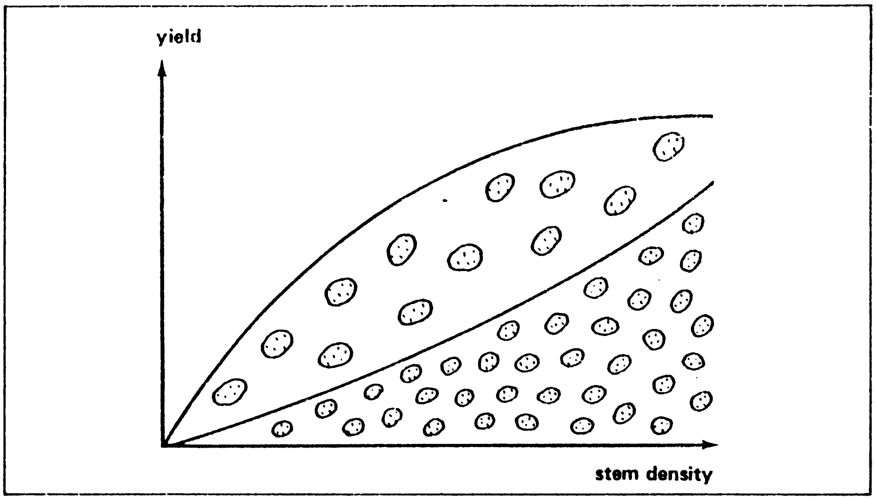
Number of Tubers

The number of tubers produced depends on the competition among stems for growth factors such as nutrients, water and light. At lower stem densities competition is less, and this results in a greater number of tubers per stem, but also a smaller number of tubers per unit area. When stem densities increase, the number of tubers per stem decreases, but the number of tubers per unit area increases.

Size of Tubers

Growth factors affect tuber size, which is limited when competition among stems is high. At higher stem densities, the tubers produced remain smaller than at lower stem densities.

TIB 1: Effect of Stem Density on Potato Production.



A high stem density increases yield up to a certain level, but reduces average tuber size (higher proportion of small tubers).

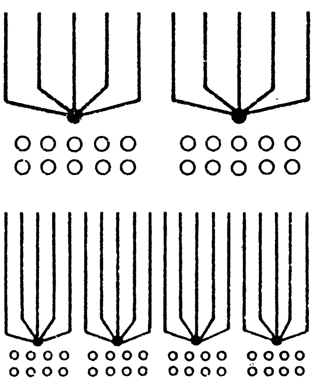
Multiplication Rate

The multiplication rate is the number of tubers produced from one seed tuber. When stem density increases, fewer tubers are produced; the multiplication rate is reduced.

3.4.3 Calculating Stem Density

Determination of stem density is more accurate at *harvest* when it is easier to separate the main stems from lateral stems. However, determination of stem density is more practical in the *growing crop*.

TIB 1: Effect of Stem Density on Potato Production.



stem number	10	
yield	2.0	kg
tuber number	20	
tuber weight	100	g/tuber
mult. rate	10	
stem number	20	
yield	2.8	kg
tuber number	32	
tuber weight	88	g/tuber
mult. rate	8	

Example: Doubling stem density does not necessarily result in doubling yield. Tuber number increases more than yield, resulting in smaller tuber size. When stem density increases, fewer tubers are produced from one seed tuber; the multiplication rate is reduced.

To determine stem density, count the number of above-ground stems per 10 meters of row at several randomly selected places in the field. Then calculate the stem number per square meter.

$$\text{Stem density} = \frac{\text{total stem number}}{\text{total row length} \times \text{row spacing}}$$

Example:

total number of stems at four randomly selected places	= 135 + 140 + 160 + 165	= 600 stems
total row length	= 4 x 10 meters	= 40 m
distance between rows	= 0.75 m	

$$\text{stem density} = \frac{600 \text{ stems}}{40 \text{ m} \times 0.75 \text{ m}} = 20 \text{ stems/m}^2$$

3.4.4 Factors Determining Stem Density

Stem density is determined by the number of main stems that emerge and survive.

The number of main stems depends on:

- Seedbed conditions: for good emergence, the soil should be moist and without clods. A dry and cloddy seedbed lowers stem density.

- Planting method: damage to sprouts reduces the number of stems, and often leads to non-uniform emergence.

- Number of sprouts planted.

The number of sprouts planted depends on:

- Number of tubers planted.

- Number of sprouts per tuber.

Table 2.

Percentage of Farmers Growing Potatoes and Estimated Yield, 1988-90
(From survey reports, Swedish Committee for Afghanistan, Peshawar)

Province	1988		1989		1990	
	% farmers growing potato	Yield (t/ha)	% farmers growing potato	Yield (t/ha)	% farmers growing potato	Yield (t/ha)
Baghlan	2	18.2	12	18.4*	7	8.6
Samangan	1	22.3	3	10.5	11	6.8
Paktia	2	6.9	7	-	7	5.6
Bamiyan	30	10.6	62	24.2*	54	16.1*
Logar	15	18.8	25	23.5	19	14.7*
Wardak	32	15.7	78	10.7*	80	12.9*
Kapisa	8	15.3	13	7.0	1	4.7
Ghazni	13	5.2	32	10.4*	27	16.8*
Paktika	5	3.1	25	3.4	21	2.0
Herat	-	-	-	-	11	7.8

* Yield data from more than 10% of farmers (1989 & 1990 only)

1.2. Production Areas

The crop is concentrated in the highland areas at elevations of 1800-2600 meters above sea level (masl). More than 80% of the total production comes from the provinces of Bamiyan, Baghlan, Wardak, Ghazni, Kapisa, Logar and Kabul (Fig. 1.). Other provinces with high elevation land also contribute a substantial quantity to the total production. In the late 1970s, Bamiyan was the most important potato growing area producing 50% of the crop. Very minor production occurs at lower elevations of less than 1000 masl in Kandahar, Kunar, Laghman and Herat.

1.3. Cropping Seasons

The irrigated highland crop is planted in April-May after the rainy season and harvested in September-October. At lower elevations the cropping season is from February to May-June.

The number of sprouts per tuber depends on:

- Seed tuber size: larger tubers have more sprouts.

- Variety: some varieties develop more sprouts than others.

- Seed tuber treatment: this includes storage, de-sprouting, cutting, and pre-sprouting. Storage conditions that favor apical dominance limit the numbers of sprouts. De-sprouting and cutting of vigorous seed tubers often increase the number of sprouts. Pre-sprouting in diffused light allows sprouts to become well developed and firm, and thereby reduces sprout damage during planting.

- Physiological age: physiologically old tubers develop more sprouts than physiologically young tubers. If tubers are too old, sprouts become too weak for successful emergence.

3.4.5 Recommended Stem Density

The crop environment plays an important part in determining what should be the recommended stem density.

Poor growing conditions caused by low light intensity, low soil fertility, low soil moisture, and poor soil structure cannot support as many stems as good growing conditions. To produce acceptable tuber size, stem density needs to be lower than under good growing conditions. High stem density under poor growing conditions may only decrease tuber size rather than increase yield.

In Europe, for example, 20-25 stems per square meter are recommended for consumer potato crops, and at least 30 stems per square meter for seed crops.

3.5 Fertilizer Requirements for Potato Production

Potato growth depends on the supply of plant nutrients, such as nitrogen (N), phosphorus (P) and potassium (K), each of which has a specific function. Lack of nutrients results in retarded growth processes and reduced yield.

A potato crop removes nutrients from the soil and replacement is necessary to maintain soil fertility. A crop yielding 4 t/jerib removes approximately 5-10 kg N, 2-8 kg P_2O_5, and 7-15 kg K from the soil for every ton produced. As only the tubers are harvested from the field, a part of this quantity of minerals remains behind. Fertilizer

application to the potato crop in Afghanistan should be within the following limits: 50-75 kg P_2O_5 (DAP), 50-65 kg urea and 40-50 kg potassium sulphate per jerib.

Fertilizer increases yield. With increased application, yield increase becomes steadily smaller until cost of inputs exceeds yield benefit. Efficient use of fertilizer both meets the land requirements and avoids excessive application.

Fertilizer requirements for a crop under specific conditions are best identified through soil analysis. In Afghanistan this service is not available, and, even when available, some resource-poor farmers are not able to afford it. In many cases, farmers have to apply quantities that are available or that they can afford, even though they realize that more fertilizer is needed to optimize yield.

Fertilizers are expensive and may not be easily available, so knowledge about the actions of the nutrients within the plants and in the soil helps the farmer use fertilizers more efficiently.

3.5.1 Nitrogen

In general, nitrogen greatly increases yield. It stimulates haulm growth and so the production potential of the crop. The nitrogen requirement depends on climatic conditions, soil type, soil fertility, the preceding crop, variety (whether long or short growing season), and management practices (especially irrigation).

Depending on all these factors, the optimal dose normally varies from 20-40 kg N per jerib.

Nitrogen is supplied by diammonium phosphate (DAP) and urea. Because nitrogen is easily leached by rain or irrigation, approximately half the nitrogen should be applied at planting time in the form of DAP and urea (approximately 12-16 kg). The remainder of the urea should be applied to the side of the ridges at earthing-up.

3.5.2 Phosphorus

Phosphorus is an essential element in plant compounds that are involved in metabolic processes within the plant. It is especially important for root growth.

Soils with high organic matter content supply sufficient amounts of phosphorus, and virgin soils have sufficient to support subsistence level crops. Soils also contain inorganic forms, but these are not always available to plants,

e.g., in volcanic soils. The potato plant uses phosphorus available in soil solution and as supplied in the form of DAP.

3.5.3 Potassium

Potassium acts in carbohydrate formation and the transformation and movement of starch from potato leaves to tubers. It is also important in controlling stomatal movement and the water status of the plant. It is the most abundant element in the plant. Potassium does not always affect yield but it has relatively more influence on the quality of the crop, dry matter content, tuber damage and storage quality.

Potash should be applied at planting. It is thought that soils in Afghanistan are rich in potash and farmers do not normally apply any to their crops. There is lack of evidence of crop response to potash in Afghanistan.

3.5.4 Methods of Application

Fertilizers can be:

- Broadcast,
- Applied in bands, or
- Placed near the seed tuber.

Fertilizer can be broadcast in the field after the furrows have been made for planting. Broadcasting the fertilizer is considered to be a drawback in areas where phosphorus and potassium become fixed quickly when mixed with the soil and are unavailable to plants. In areas where high fertilizer rates are applied, soil fertility is high, and no fixation takes place, broadcasting fertilizer is a good practice.

If the levels of soil fertility and fertilizer application are low, placement of fertilizers is advantageous. Placement of fertilizer either mixed in the soil beneath the seed tuber or between the seed tubers in the row puts the nutrients close to the root system. This is highly advantageous but is time-consuming. Most farmers apply the fertilizer in a band in the base of the furrow. With this method the fertilizer must be mixed with the soil before the seed tubers are placed in the furrow. The seed tubers should not be allowed to come into direct contact with fertilizer.

3.6 Water Supply for Potato Cultivation

3.6.1 Importance of Water

A crop in full growth with a closed canopy (all the ground covered by green foliage) can transpire 2-10 mm water per day. That is equivalent to 20,000-100,000 liters per hectare per day, or about 1/2 to 2 1/2 liters per plant per day. At a plant population of 40,000-50,000 plants per hectare, this corresponds to 100 to 200 liters per plant per season. More than 95% of the water that is taken up by the roots is lost to the atmosphere by transpiration, only a very small part being used for growth.

Correct water management provides sufficient water for potato growth and avoids excessive loss or waste of water. Compared to many other crops, the potato plant is sensitive to both lack and excess of water:

- Potato's relatively shallow root system limits the so-called *effective root zone* to 50-80 cm soil depth.

- The root system is weak and cannot penetrate compacted soil. This reduces the effective root zone even more.

- Root penetration may be restricted when the pH of the different layers in the soil profile vary.

- The suction power of potato roots is relatively low. Additionally, efficiency of roots may be affected by diseases and pests.

- The stomata of potato leaves close quickly upon lack of humidity. Stomatal closure leads to reduced transpiration and photosynthesis, heating of the leaves, and subsequent reduced yield.

3.6.2 Lack of Water

Lack of water is the most common stress. The potato does not compensate for drought periods by prolonged growth. Even a short period of drought affects the yield, especially after tuber initiation.

Dry soil causes reduction in the number of stems. In a dry and cloddy soil only sprouts that have access to water develop.

Drought influences yield directly by restricting transpiration and photosynthesis. Indirectly it leads to reduced evaporation from the soil and leaves, thereby increasing soil and plant temperature. High temperature is unfavorable to tuber initiation. Drought also contributes to tuber defects, and dry soils form clods that make soil and crop management difficult and cause tuber damage at harvest.

3.6.3 Excess of Water

Excess water may be caused by heavy rainfall, heavy irrigation, or inefficient drainage. Waterlogging of parts of irrigated fields can be the result of poor land levelling.

Too much water prevents oxygen from reaching the underground parts of the potato plant, and this results in poor root development and rotting of the newly formed tubers. Seed tubers (and cut seed pieces) are especially susceptible to tuber rot.

High moisture favors development of late blight (*Phytophthora infestans*). Excess water results in waste due to percolation and surface run-off. It also increases erosion.

3.6.4 Variation of Soil Moisture

Excessive variation in soil moisture affects tuber quality.

Water after a prolonged drought may cause secondary growth: tubers form bottle neck-like or knobbly shapes and may crack. New haulm growth may be at the expense of tuber yield. A restarting of tuberization results in formation of many small tubers.

3.6.5 Water Requirement During the Growing Season

Period between Planting and Emergence

The soil around the seed tuber should be moist but not wet. If the farmer has access to water at any time, irrigation should be done with great care and only a small amount of water applied each time.

At and after planting under high temperature conditions it is extremely important that the soil in the ridge is kept moist in order to decrease the temperature.

Insufficient water supply at this period may cause:

- delay in and an uneven emergence or even total failure, and
- a reduced number of stems per plant.

Over-irrigation may cause seed tuber decay and thus blank spaces in the rows.

Period Between Emergence and Tuber Initiation

Water supply at tuber initiation (swelling of the stolon tips) influences common scab (*Streptomyces scabies*) attack on the tubers and the number of marketable tubers per plant at harvest. Moist soil around the newly formed tubers for a period of about three weeks can protect the tubers from scab attack. If common scab is a problem, a few light irrigations during this period are recommended.

Period after Tuber Initiation (Bulking Period)

During bulking the crop needs a lot of water. Insufficient water results in reduced yield.

There should always be an even distribution of water to ensure regular growth of the tubers. Uneven distribution of water may cause second growth or misshapen tubers. Thus water supply not only greatly affects tuber yield but also tuber quality. Water is, therefore, one of the key factors in potato production.

Period Immediately Before Harvest

If the crop is grown under irrigation, water should not be applied during the last 7-10 days before harvest. The timing of the final irrigation will depend on the temperature and the stage of maturity (senescence) of the crop.

The soil must not be allowed to dry out completely, especially when the temperature is high, because harvesting will be difficult and tubers will be damaged.

Tubers near the surface in dry soil that is exposed to the sun will develop physiological defects such as internal brown spot (net necrosis).

3.6.6 Furrow Irrigation

Furrow irrigation is the oldest system and still applied in many parts of the world.

The advantages of furrow irrigation are:

- low investment, and
- no wetting of the foliage (favorable in preventing foliage diseases and when using saline water).

The disadvantages are:

- high labor demand,
- low application efficiency (run-off, percolation, and inadequate distribution; only 50-70% of the water applied will be used by the crop), and
- obstacle to mechanization.

Furrow Distance

The distance between irrigation furrows varies from 60 to 90 cm depending on the soil texture. In sandy soil, water leaks away rapidly and does not reach far; the distance between rows should be smaller than in clay soils. In coarse sandy soils the distance between furrows should preferably be about 60-65 cm, and in heavier clay soils about 70-80 cm.

Furrow Length

Make furrows as long as uniformity of water supply and furrow slope allows. The maximum furrow length will depend on the slope of the furrows, soil type and recommended depth of water in the furrow. Water should not exceed half the ridge height to avoid excess moisture in the tuber region. If only small quantities of water are applied at each irrigation, the length of the furrows will have to be short.

In poorly levelled fields, short furrow irrigation is necessary. This requires more space for auxiliary supply channels and is more labor intensive.

Furrow Slope

Serious erosion occurs when a furrow slope exceeds 2% (2 m per 100 m row length). In mountainous rainfed areas, intense rains can cause erosion in slopes in excess of 0.3%. When the field surface is uneven, furrows on the contour help prevent erosion and water loss.

Ridge Uniformity

Uniform ridges permit an even distribution of water to the potato plants.

3.7 Potato Pests and Diseases

3.7.1 Pests

Insect Control

Insects can cause direct or indirect damage to crops. Indirect damage is caused by the fact that insects (mainly aphids) are vectors of viruses. In ware potato production, insect control concentrates mainly on the prevention of direct damage, while in seed production both direct and indirect damage should be prevented.

Measures to control direct damage include the use of insecticides, although there is growing concern over their use (environmental pollution, build up of resistance, danger to humans, etc.). In some cases a certain

level of attack has to be accepted, especially foliage damage, when insecticidal control is not economic.

Depending on the pest, chemical control can be through:

- foliar application of insecticides,
- soil application of insecticides to the growing crop,
- application of chemical to the soil at emergence,
- chemical applied and mixed with the soil before planting, or
- treatment of tubers in store.

Cultural practices, such as crop rotation, proper soil tillage, soil drainage, and a good ridging system, are very important in reducing pest infestation.

Most pests can be controlled at the time they appear, but measures to control white grubs and wire worms have to be carried out in advance whenever an attack may be expected. For some insect pests, such as potato tubermoth, more than one control method has to be applied.

Cutworms (*Agrostis* spp. and other Noctuids)

These nocturnally active moths are distributed worldwide. Damage is caused by the larvae. Most cutworms are about 50 mm long and curl their body into a tight ball upon disturbance. The **black cutworm** consumes or "cuts" stems near the soil surface. The **armyworm** consumes foliage, and **subterranean cutworms** cause damage by gnawing cavities into tubers, especially those near the soil surface.

A potato crop following after grasses or cereals is likely to suffer from cutworm attack. Good ridging reduces attack on tubers, and insecticides can also be mixed into the soil before planting. If cutworms become a problem after planting, the soil surface can be dusted with insecticide.

Most cutworms can be controlled with baits prepared by mixing proprietary insecticides such as dipterex with wheat bran, molasses and

water. The baits are distributed around the plant stem bases shortly before dusk.

Aphids

The most important aphid infesting the potato crop is the green peach aphid, *Myzus persicae*. Aphids do more damage by transmitting virus diseases than by feeding on the plants. *Myzus persicae* is also the most important and efficient vector of potato leafroll virus and potato virus Y (PVY).

Aphids transmit viruses in two ways:

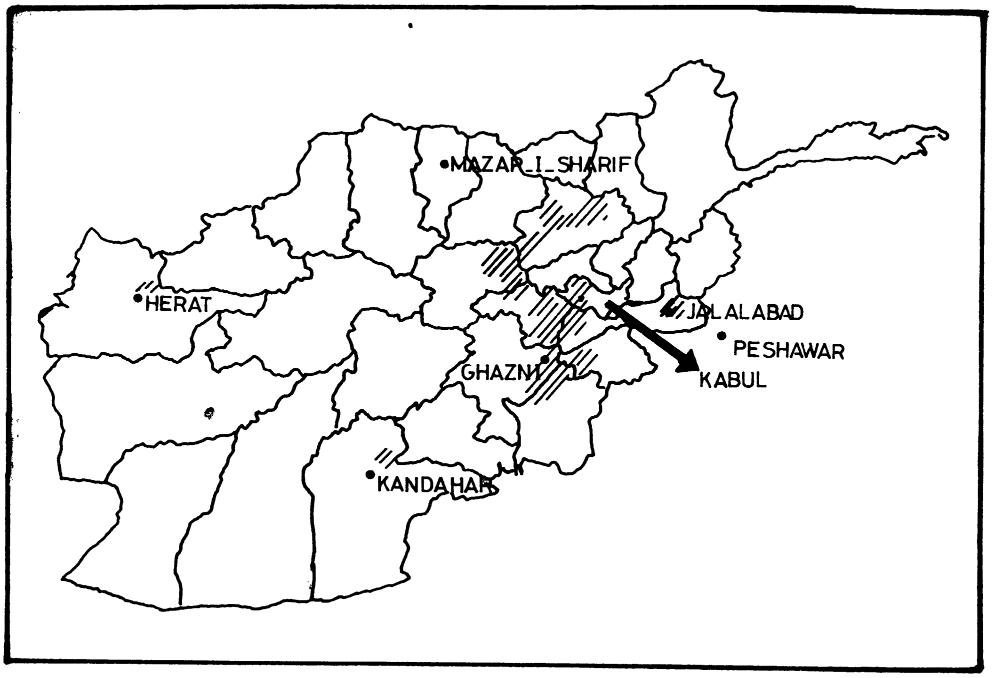
- non-persistent transmission, and

- persistent transmission.

<u>Non-persistent transmission</u>. Aphids may acquire viruses during a brief period of probing or feeding on the epidermal tissues of infected plants. It may take only a few seconds for the mouth parts to become contaminated, and then aphids can transmit viruses immediately to other plants. Aphids remain infective for a relatively short period, usually not more than two hours, and viruses can only be carried over short distances. The group of potato viruses that are transmitted non-persistently include PVY, PVA and PVM. Within a field, insecticides may slightly reduce virus transmission, but they cannot prevent it; neither can they control infections from outside the field.

<u>Persistent transmission</u>. Viruses that are persistently transmitted are located in the phloem tissue of the plant, and this group is represented by potato leafroll virus (PLRV). The aphid must feed on the phloem for at least 20-30 minutes to acquire the virus. The virus enters the aphid's body, and after a latent period of several hours, the aphid is able to transmit the virus. The aphid remains infective for the remainder of its life and can therefore carry the virus over long distances. Insecticides can greatly reduce PLRV spread within a field, but they cannot control infections from outside by migrating aphids.

Fig. 1. Potato Production Areas in Afghanistan.



1.4 Varieties and Seed Source

Two local white-skinned varieties called *Garma* and *Sarda* dominate potato cultivation, the latter being more widely grown. It is not known if these are distinct varieties or if the latter appears different from *Garma* because it shows leaf crinkle that could be caused by virus infection. In the 1970s an Indian aid program tested several Indian varieties and imported small quantities (100-150 t) of seed tubers, mainly *Kufri Chandramukhi* and *Kufri Lauvkar*. These varieties were widely distributed but not accepted by consumers. There is no information on their success in replacing the local varieties in those areas where they were introduced.

There is no importation of seed tubers nor a seed production scheme within the country. Farmers either retain some of their harvest as seed tubers or purchase planting material from their neighbors or the local market.

1.5 Production/Productivity Constraints

Discussions with Afghan staff of the Afghanistan Agricultural Sector Support Program/Private Sector Agribusiness (AASSP/PSA), including field extensionists

3.7.2 Diseases

Integrated control

There are specific methods of control for each disease, but in commercial potato production several diseases are usually controlled at the same time. The methods used to control some of the major diseases often include the control of minor diseases that would otherwise not merit separate control measures. It is important to know each disease and its particular control measure so that, in practice, the total control system can be adjusted according to any particular circumstance.

Diseases are only controlled to a certain degree and it would be impossible or, if possible, too expensive to effect complete control. The degree of infection that can be tolerated depends on the threat posed, the losses (quantitative and qualitative) caused, and the purpose of the crop (consumption or seed production).

Reduction of Crop Losses

Diseases may cause crop losses due to:

- seed decay or attack on the sprouts leading to a poor stand,
- attack on the leaves by fungal diseases causing a reduction in the growing period with consequent low yields,
- reduced haulm growth and a decreased assimilation caused by virus diseases,
- wilting plants due to bacterial or fungal infection also resulting in a reduction in the growing period with consequent low yields,
- lesions in the tubers,
- tuber rotting during the growing season or during storage,
- attack on the root system,
- skin blemishes caused by fungal diseases resulting in lower prices, or

- misshapen and smaller tubers.

Besides losses in the current crop, the consequences of diseases carried over by the tubers to the next crop should also be taken into consideration.

General Methods of Control

Most control methods are not sufficient on their own to provide effective control, and a combination of various methods will have to be adopted.

Cultural practices: Soil tillage helps control weeds and groundkeepers (which can carry over diseases to the next crop), and promotes rapid emergence, important for reducing losses due to seed decay and attack by pathogens such as *Rhizoctonia*.

When specific disease cycles are known, control may be possible by changing planting dates. Proper ridging practices control weeds and provide appropriate environments for tube development. This practice also discourages infestation of some fungal diseases.

- o Seed preparation: Presprouting assists in rapid emergence and lessens attack from *Rhizoctonia*. Cutting seed tubers, the normal practice in Afghanistan, increases the risk of spreading diseases such as contact-transmitted virus diseases (e.g. PVX) and bacterial wilt during the cutting process. The cut surface allows easy entry for soil pathogens that cause seed piece decay.

- o Water supply: Many pathogens can enter the tuber if the soil is very wet, as the lenticels are open. Over-irrigation at tuber initiation increases the chances of common scab disease. Very wet soils after planting increase the number of seed pieces that decay.

- o Roguing: (removing plants from the field) is important in the control of virus disease spread in crops grown for seed production and to ensure a low percentage of infected tubers at harvest.

- o Haulm destruction immediately before harvest greatly assists in lessening the chances of fungal and bacterial diseases

being spread from the foliage to the surface of tubers. Tubers so contaminated can eventually rot if storage conditions are ideal for pathogen growth.

o Harvest, handling and storage: Tubers that are damaged due to bad harvesting techniques and poor handling are at greater risk from entry of pathogens and rotting in storage. Diseased and damaged tubers should be discarded during grading and the tuber surfaces should be dry before the potatoes are put into the storage pits or other storage facilities.

Use of Clean Seed: Seed tubers should be free from diseases and pests that can survive in the soil and are difficult to control, e.g., *Pseudomonas solanacearum* (bacterial wilt) and nematodes. Tuber-borne diseases which will reduce yields, e.g. virus diseases, also spread in the crop, but will not contaminate the soil. All tuber-borne diseases will be carried over to the following crop.

Tuber Disinfection: Treatment with chemicals is carried out in many countries but can never replace high quality, disease-free seed tubers or proper handling and storage. This type of treatment is not recommended for Afghanistan due to non-availability of the chemicals and cost involved.

Soil Treatment: Treatment to control soil-borne pathogens, insects and nematodes can be done but is not recommended because it is expensive.

Foliar Application of Fungicides: Diseases caused by such fungi as *Phytophthora infestans* (late blight), *Alternaria solani* (early blight) and *Cercospora* sp. (Cercospora leaf spot) can be controlled by foliar application of fungicides. The fungicides do not have a curative effect but are only protective. One of the most widely used and available fungicides is the dithio-carbamate compound Dithane M-45. Cupronit Blue is also common in Afghanistan. The interval of spray application will vary from 3-20 days depending on the weather conditions. The crop has to be sprayed every few days if heavy rainfall washes the fungicide off the leaves.

Rotation: Rotation is a common practice and checks the build-up of pathogens in the soil. It is also used to reduce the level of soil infestation once soil has become heavily contaminated, e.g., *Pseudomonas* (bacterial wilt), *Globodera* (golden nematode).

Isolation: Neighboring fields can be a source of infection, e.g., late blight, virus diseases. In some countries, when farmers are growing crops for the production of seed, they attempt to isolate their potato fields to reduce the spread of diseases, especially the aphid-transmitted virus diseases. This situation is not practical in a country like Afghanistan due to the small fields and the intensive cultivation in farming areas using canal irrigation.

Late Blight (*Phytophthora Infestans*)

This is the most serious fungal disease of potato and is found almost everywhere the crop is grown. The disease, if not controlled in the early part of the season, can completely wipe out a crop. Later infection can greatly reduce yield. The disease can enter the crop from:

- an infected tuber that has been planted. These usually rot but sometimes sprouts emerge and carry the disease from the tuber;

- infected tubers found in piles of potatoes discarded the previous season and left on the farm;

- neighboring potato fields; and

- other host plants, e.g., tomato.

The earliest symptoms are often found on the lower leaves. They consist of small pale spots that turn into brown or black lesions. The lesions expand until all the leaf is necrotic. Spores, which are responsible for spread of the disease, are found on the underside of the leaf as a white mildew surrounding the lesions. Spores are formed and spread when weather conditions are favorable (dull, humid, rain, wind, and temperatures between 15-20^{0}C). Under ideal conditions, the disease can spread from a few infected plants to all the plants in a field. Spread can be checked if the crop is sprayed when the first lesions are observed. There are no varieties that are completely resistant, but some varieties show high levels of tolerance to infection. Breeding programs are developing material to

select varieties of potatoes that will either not require spraying or only one or two applications of fungicide. Most local varieties in Afghanistan are susceptible to late blight.

Early Blight (*Alternaria Solani*)

This can be an important disease in many of the warmer potato-growing areas. The disease occurs on foliage and sometimes on tubers. If tubers are heavily infected, losses in storage can be substantial.

More or less circular, dark-brown lesions first appear on the lower, older leaves. With heavy infections the leaves turn chlorotic, dry and die, and lead to defoliation. The fungus survives from season to season on plant debris, and this is the main source of primary infection in a crop. The spores are spread by wind. Foliar infection (spread from plant to plant) is favored by warm (about 25^0C) and wet conditions. Rainfall is not required if heavy dew is frequent.

Infected plant debris (dead haulms) should be removed from the field after harvest. The fungus can survive on plant debris for several years in the soil, therefore crop rotation may help to reduce inoculum in a field. Early blight can be effectively controlled by fungicide sprays (the same fungicides as are used against late blight) provided that application is timed to coincide with the secondary spread of spores from plant to plant. This occurs after the disease has become established on the lower leaves, following infection from plant debris on the soil surface.

3.8 Potato Harvesting and Handling

The time of harvest is usually dictated by the maturity of the crop, although a farmer may wish to harvest early in order to get a higher price for his produce in the market. Apart from yield, the quality of an immature crop is influenced by early harvesting. The skin of an immature tuber is weaker and more susceptible to damage, thereby increasing the likelihood of infection by fungal and bacterial pathogens.

3.8.1 Haulm Destruction

It is common to cut, pull out, burn or destroy haulms before harvesting. In many countries this is done with chemicals, but cutting the haulms by hand is just as effective although costly in labor. The haulm is destroyed to facilitate harvest and to allow the skin of the tuber to harden.

Green haulms should be cut or the haulms should have died back at least 10 days before harvest. If the crop is very immature, more than 10 days are required to allow the skins to harden. If the weather is hot and dry at harvest time, the soil dries out and heats up very quickly once the haulms are dead or removed. The soil exposed to the direct sun should not be allowed to dry out nor the soil temperature exceed 30^{0}C. Under these conditions tubers that are near the surface of the soil will develop a physiological condition known as internal heat necrosis and rot.

Haulm destruction, especially when the potatoes are not yet mature, greatly affects the release of the tubers from the vines at harvest. As tubers can be attacked by micro-organisms such as *Rhizoctonia solani* and by pests during this period, the time interval between haulm destruction and harvesting should not be too long.

3.8.2 Harvesting Operations

Harvesting potatoes includes the following operations:

- digging,
- collecting the tubers in the field,
- grading,
- bagging, and
- transport to the farmhouse, store or market.

The aim of each harvesting operation is to take the tubers from the soil to the store or market as cheaply as possible, keeping losses in quality to a minimum.

The harvesting system used depends on:

- the economic situation (labor costs, market price)
- the quantity of potatoes to be harvested and the time available
- the size, shape and situation of the potato field
- the soil and weather conditions, and
- the use to be made of the potatoes (immediate consumption, storage).

Digging

The ideal condition for digging the crop is a dry day when the soil is dry on the surface but still moist around the tubers. Digging should be

done, preferably, early in the morning and, during hot sunny weather, discontinued when the sun begins to make the tubers warm.

When digging with hand implements, great care should be taken to ensure that tubers, especially those at the side and in the base of the ridges, are not damaged. Poor digging can reduce the quality of the produce and the farmer's income. It is often responsible for losses in storage caused by rotting; cut and damaged tubers allow easy access for fungi and soft rotting bacteria.

Harvesting should be discontinued before mid-day if the temperature is high and the tubers exposed on the surface of the soil are becoming hot.

Collecting the Tubers in the Field

The tubers have to be collected from the rows and brought to a number of places in the field, ready for grading and bagging. Again care must be taken in handling the tubers during this operation.

If the weather is sunny, the pile of tubers should be covered with haulms to keep them cool, or placed under trees or in some other shaded area.

Grading

When the potatoes are to be sold directly in the market, grading for size may not have to be done, but cut and damaged tubers should be excluded so that quality is maintained.

When damaged tubers are bagged with sound tubers, and the bags are transported and stored before the produce is sold in the wholesale or retail market, rotting may occur and result in large losses. If the farmer still owns the potatoes in storage, he is going to lose money. If the transporter or wholesaler has bought the potatoes at the farm, he is not likely to purchase from the same farmer in the future. Farmers should build up a reputation for quality produce.

The farmer who stores seed tubers for his own use and for sale during the following year must pay particular attention to grading. Whenever possible, seed-size tubers of 30-50 g should be selected, or larger ones that need only be cut into two pieces. All tubers should be sound,

with no skin abrasions or cuts, nor any sign of fungal or bacterial infection or nematode infestation. These tubers should be completely free of soil, which can act as a source of infection in storage.

3.9 Potato Storage

3.9.1 Introduction

If there are only one or two harvests per year, potatoes need to be stored to ensure a regular supply and to obtain higher market prices. To ensure that farmers have tubers of the correct physiological stage for planting, adequate storage methods for seed tubers are essential.

It is important to determine which storage method is the most appropriate. The method used will depend on:

- purpose of the crop (consumption, seed),
- duration of storage,
- outside temperature during storage,
- quantity of potatoes to be stored, and
- method of handling.

The storage life of a potato depends on:

- storage temperature,
- quality of the crop, and
- variety.

3.9.2 Storage Losses

Losses are unavoidable and are due to:

- evaporation
- respiration
- sprouting
- infection by fungi and bacteria
- infestation by insects

Storage life of tubers kept at different temperatures

Temperature (^0C)	Months in Storage		
	Consumption (dark)	Seed (dark)	Seed (diffused light)
4	10	10	11
10	5	6	9
15	4	5	8
20	3	4	6

Storage condition should be such that:

- losses are kept to a minimum,
- tubers are brought to and kept at the right physiological stage; and
- the chemical composition of the tubers is brought to and maintained at the desired quality.

3.9.3 Evaporation Losses

The potato tuber consists of 80% water, and the main weight loss during storage is water loss, which reduces quality. Water evaporates through the skin, wounds and sprouts. The ratio of the amount of water loss per unit area of skin, wounds and sprouts is 1:300:100, respectively. Evaporation is relatively high if tubers are damaged or have a weak, injured skin. Sprouting also leads to high evaporation losses.

Ventilation--the circulation of air--is essential to keep the surface of the tubers dry, to remove heat and supply oxygen. Therefore, water losses will always occur, and these are approximately 1.5% of the fresh weight in the first month and 0.5% in subsequent months.

Losses caused by evaporation depend largely on:

- the ventilation rate,

- the duration of ventilation, and
- the relative humidity or vapor pressure deficit of the air used for ventilation.

3.9.4 Respiration Losses

A potato tuber is a living organism and therefore respires. Oxygen, absorbed from the atmosphere, and carbohydrate from the tuber are converted into carbon dioxide, water and heat. The respiration rate and the production of heat depends on the temperature of the tubers. Other factors affecting the respiration rate are:

- maturity of the tubers,
- presence of wounds, and
- oxygen content of the atmosphere.

The heat produced in storage due to respiration should be removed by ventilation. If more heat is produced than is removed, over-heating occurs. This is the case when ambient air temperature is relatively high, the respiration of the tubers is high and the ventilation is poor.

To avoid oxygen starvation of the tubers (causing a condition called black heart), the carbon dioxide must be removed and replaced by oxygen. The air surrounding the tubers should be replaced with fresh air from time to time. At least 4-5 cubic meters of fresh air is needed every 24 hours per 1,000 kg of potatoes to supply sufficient oxygen for the respiration process.

3.9.5 Sprout Growth Losses

Sprout growth causes excessive losses due to:

- evaporation,
- increased respiration, and
- transfer of carbohydrate from the tuber to the sprouts.

During the first three months when the tubers are dormant, no sprout growth occurs. Temperature has no effect on the length of the dormant period, but it does have an effect on sprout growth. With increasing temperature, sprout growth accelerates. Moisture also stimulates sprout growth. Light reduces the growth of sprouts, and diffused light is very effective when storing seed potatoes.

attending the Agricultural Development and Training (ADT) Summer Training Course, reveal the most important factors limiting potato growing and improvement in productivity levels are:

- o Not enough labor
- o Unavailability of seed tubers
- o Poor quality seed tubers
- o Lack of agricultural inputs, especially fertilizers
- o Post harvest storage loss
- o Poor agronomic practices
- o Diseases and pests
- o Marketing problems

1.5.1 Not Enough Labor

Potato cultivation is labor intensive, especially at planting, weeding and ridging, and harvesting. The crop needs continual attention during the first five to six weeks when weeding and ridging operations must be carried out, and for irrigation throughout the growing season--every 7-10 days in the plains and every 12-14 days in the highlands. Reduced animal traction power for seedbed preparation, due to loss of animals during the civil strife, also exacerbates problems caused by a lack of manual labor. Insufficient labor is probably the most important factor in reduced cultivation of the crop.

1.5.2 Unavailability of Seed Tubers

For farmers who are returning to growing potatoes, and who have not accumulated their own stock of seed tubers, the unavailability of seed tubers in the market at planting time could also contribute to the reduced area of production. However, this should not be regarded as important in and around major potato-growing areas.

3.9.6 Losses Caused by Fungi, Bacteria and Insects

Diseases and pests can cause major losses during storage. Potatoes should be carefully graded before being put in storage in order to remove damaged tubers or any tubers showing signs of fungal or bacterial infections or insect infestation.

Good ventilation that reduces the temperature and removes free water from the surface of the tubers will help to reduce losses caused by fungi and bacteria. The important organisms causing soft rots are:

- *Erwinia* spp.
- *Pseudomonas solanacearum*
- *Corynebacterium sepedonicum*
- *Pythium* spp.
- *Phytophthora infestans*
- *Phytophthora erythroseptica*

Organism causing dry rots (*Fusarium* spp., *Macrophomina* sp., and *Phoma* sp.) may spread and cause serious losses.

Other fungi that do not cause rots, such as *Rhizoctonia solani*, but found on the outside of the tuber skin, may spread in storage and reduce tuber quality.

3.9.7 Physiological Stage

Potatoes for consumption should have little or no sprout growth at the end of the storage period. The storage temperature will depend on the length of the storage period required.

Seed potatoes should be stored so that the tubers sprout and emerge quickly immediately after planting. As with consumption potatoes, the storage temperature will determine the length of time that the tubers can be stored. Diffused light will prolong the storage period of seed potatoes.

3.9.8 Factors Affecting the Keeping Quality of Tubers

There are only a limited number of factors that enhance the keeping quality of stored potatoes. These are:

- good tuber quality and skin,

- proper ventilation,
- low temperature,
- low moisture and humidity,
- light (seed tubers only), and
- chemicals (sprout depressants).

Tuber and Skin Quality

Storage will only be successful if the tubers entering the store are sound and have a good skin which is not damaged. Cultural practices and disease and pest control during the growing season influence the quality of the skin. Immature tubers are difficult to store as they have low dry matter content and weak skins.

Before putting potatoes into permanent storage, it is advisable to put the tubers into temporary storage for one or two weeks to allow the skins to cure properly and for disease symptoms to become more visible. This improves the selection process.

If potatoes are to be kept in cold storage at 4^0C, they should be kept at 15^0C for the first few weeks to allow the skins to cure before the temperature is lowered.

Ventilation

Ventilation is needed to remove heat, water and carbon dioxide, and to supply oxygen. Natural or forced draught ventilation can be used to ensure that the air passes through the heaps of potatoes (bulk storage) or bags of potatoes.

Natural ventilation of pit stores that are completely closed is not possible, and overheating occurs. This results in heavy losses. Pits are sometimes fitted with chimneys to allow the hot air to escape, but air movement is restricted. If the pit design can allow for an opening to permit air to enter at the base of the pit (as used by farmers in Bamiyan), then greater cooling of the tubers can be obtained.

Temperature

Temperature largely determines how long potatoes can be stored. Temperature is determined by climatic conditions, method of storage and storage design.

Tubers left in the soil will have the same temperature as the soil. A system of "delayed harvest" may be applied up until the end of the dormancy period in regions with moderate temperature and well drained soils.

The rise in temperature in storage pits in the ground results in over-heating, excessive sprouting and substantial losses due to fungal and bacterial soft rots.

Moisture and Humidity

During storage, potatoes should be kept dry, but excessive loss of water should be avoided. If harvested wet, potatoes should be dried before storage, or by initial continuous ventilation if placed in a ventilated store. Free moisture on the surface of stored tubers provides ideal conditions for the spread of diseases.

Light

Light is a good alternative to low temperatures when storing seed potatoes. When keeping potatoes in diffused light, their storage life can be prolonged.

3.10 Seed Production: On-Farm Improvement of Farmers' Seed

The sources of seed tubers for planting are:

- farmer's own seed
- neighboring farmer
- local market
- recognized seed grower
- government seed production scheme

Farmers in Afghanistan are not able to buy certified or improved seed potatoes because there is no seed scheme within the country and there is no importation of seed tubers.

Those farmers who grow potatoes at low elevations are unable to keep tubers from one planting season to the next and therefore must purchase seed tubers in the local market or from another province where the crop is grown at higher elevations and stored from one year to the next. In these highland areas some farmers will have poor crops with a high percentage of virus and other diseases that are transmitted in the tubers. With these types of crops it is very difficult, but not impossible, for farmers to improve the health status of their stocks. When crops contain a reasonable percentage of healthy-looking plants, it is very easy to improve the quality of the seed tubers that farmers save for their next year's crop.

The principle behind the method is one of positive selection, i.e., the selection of healthy-looking plants to provide tubers for the following seed crop. The method is known as the **seed plot technique** and is described in section 2.2.

3.11 Roguing Potatoes

Roguing is a control technique in which infected plants are identified, dug up, removed from the field, and destroyed. By roguing, farmers eliminate plants that produce diseased seed tubers as well as contamination sources within a crop. Roguing can also be used to eliminate "off-types" or plants of other varieties from a crop.

Roguing, also referred to as "negative selection", involves selecting undesirable plants to be removed from the field. These plants are selected on the basis of visible symptoms.

Roguing is impractical in fields where most of the plants are infected. In such cases, use "positive selection", a process in which only the best plants are selected and reproduced.

How thoroughly a field is rogued depends on the use of the produced seed. Because of economic reasons, farmers are often reluctant to eliminate plants, even those with serious diseases. Experiments have shown, however, that the remaining healthy plants fill up the empty spaces and compensate for this plant loss by producing higher yields, especially when roguing is carried out early in the growing season.

The types of plants to be rogued fall into the following categories:

- diseased plants

- atypical plants
- volunteer plants

Diseased plants that should be rogued out are those infected with systemic diseases, especially virus and bacterial diseases. The symptoms of the different diseases should be known so that infected plants can be recognized and removed.

Atypical plants include those of other varieties and plants with cytoplasmic and genetic variation. It is important to be able to recognize the varieties that are grown within a country so that varietal purity can be maintained.

Volunteer plants grow from tubers that remain in the ground from the previous season. These plants affect varietal purity and can be a sources of infection and hosts of the first insects that appear in the crop. Volunteer plants usually emerge earlier than the planted variety.

3.11.1 Roguing Procedure

Roguing should begin immediately after infected or undesirable plants are detected, usually a few days after emergence. The sooner the infected plants are removed, the less chance there is of disease spreading to healthy plants in the crop. Roguing should continue during the season as long as it is possible to pass between the rows without touching the foliage.

Roguing consists of four basic steps:

- Identifying plants to be rogued,
- Digging up plants, including the tubers, stolons and roots,
- Removing the plants from the field, and
- Destroying the plants.

Identifying plants

Once you are familiar with the growth characteristics of a variety, it is very easy to identify plants that do not appear healthy. Stay at least one row away from the plants that you are checking in order to be able to compare groups of three to five plants.

Digging up plants

Systemic diseases such as those caused by viruses and bacteria infect all the vegetative parts of the plant. Therefore, it is essential to remove all the plant, including the very small tubers, stolons, and even the mother tuber. If not, regrowth may start another source of infection. Use a fork or other digging implement to remove the plant from the soil. Do not pull the plant up by hand as parts may break off and remain in the soil. Sometimes it is necessary to remove the adjacent plants (in the row) to the infected plant, especially with diseases like bacterial wilt where bacteria in the soil can infect neighboring plants through the root system.

Removing Plants From the Field

To avoid disseminating infective aphids and soil from around the roots of bacterial diseased plants, carefully place the plants in bags. If aphid populations are high, it is advisable to spray the crop before roguing to kill the vectors and reduce virus spread.

Destroying Plants

Bury or burn the infected plants.

IV. POTATO GROWING AREAS IN AFGHANISTAN

The majority of the potatoes grown in Afghanistan are found in three areas: low elevations of less than 1000 masl, mid-elevations of 1000 to 1600 masl, and higher elevations of 1800 to 2600 masl. The areas of low elevations producing potatoes are found in Kandahar, Nangarhar, and Laghman. Baghlan is located in the mid-elevation category. The high elevation provinces are Kabul, Logar, Ghazni, Wardak, and Bamiyan. Certain management and marketing factors should be considered when growing potatoes in these different areas.

When potatoes are grown at higher altitudes, it will normally take longer for the crop to mature. This is partially reflected in the harvest times for potato in Afghanistan. At the lower elevations potatoes will be harvested in the months of June and July while at the higher elevations, September and October are normal harvest months. Early planting and/or planting earlier maturing varieties are important for the higher altitude areas.

In general, soil fertility levels are better in the provinces of Nangarhar, Baghlan and Kandahar. Even so fertilizer will need to be added at all locations in Afghanistan for a good yielding potato crop.

The severity of attack of the major potato diseases will be influenced to some extent by the area where the crop is grown. In the different altitudes where potatoes are grown, the micro-climates vary considerably. In general, diseases such as late blight, rhizoctonia, and early blight are more prevalent under conditions of high humidity and moderate temperatures. Excessive moisture conditions favor the spread of fusarium wilt.

The ability to store the potato harvest should be a consideration when determining if potatoes are grown for seed or for human consumption. With proper management potatoes can be stored at the higher altitudes. The cooler storage temperatures prevent potatoes from sprouting when over-wintered. Adequate storage makes it feasible to produce seed potatoes at the higher altitudes and very difficult for the lower altitudes. It is also easier to control the virus transmitting insects in the cooler temperature climates usually found at the higher altitudes.

APPENDIX I

NOTES ON WORKING WITH FARMERS

Many agricultural scientists, both researchers and extensionists, do not credit small, resource-poor farmers with knowledge about how to grow good crops and attain high yields. Farmers, often with the help of their family, work on their farms to feed and clothe their family and educate their children.

Farmers have to make a profit and are very shrewd economists. Many of the things they do, for example, the cultural practices they employ, are based on experience, often gained through many generations of farming the land. The decisions that are made regarding crop husbandry and post-harvest techniques are not based solely on biological findings; consideration must be given to both economic and social factors that impinge on farming practices. The time of planting a crop may be determined by the availability of labor (a social consideration), and the seeding rate and quantity of fertilizer applied may depend on the amount of money available to purchase inputs (an economic consideration). Often, farmers do not follow government recommendations of production practices, not because of their inability to understand and appreciate improved cultural practices that will maximize yields, but because of lack of money for the purchase of inputs, the financial risks involved or marketing problems.

The first thing an extension worker must do when working with a farmer is to develop a friendship and understanding, and then secure his interest, cooperation, support, and assistance. The farmer must be regarded as a resource person and not someone who needs to be taught or shown how to do the job properly.

When you are working with a farmer to help him overcome production constraints and improve his yields and income, he must be involved in the problem-solving exercise and decision-making process from the very beginning. Extension staff often think <u>they</u> know why a farmer is not getting good yields. Problems that the extensionist sees as important are not seen as important by the farmer, as the farmer's perception of constraints is not motivated by the same biological information.

When going to a farm, always prepare your visit well beforehand so that the farmer knows when you are going to arrive. It is no use "dropping in" on a farmer who is in the middle of something very important on his farm. Also prepare for your visit and work out what you actually want to achieve. The visit must be structured and undertaken for definite reasons; if the objective is not clear, you are wasting your time as well as the farmer's.

Never meet with the farmer in the village market or in his house if you want to discuss the potato crop growing in the field. When possible meet on the farm where you can relate to things that are happening around you--even if they involve crops other than potatoes.

The farmer must not get the feeling that he is being interviewed or questioned about how and why he does certain cultural practices or other farm operations. Do not approach him with your notebook and pencil in your hand, ready to write down everything that he says. This behavior can be threatening. By talking to the farmer and asking the right sort of questions, you will be able to build up a picture of how the crop is grown and what problems are encountered during the growing season, at harvest, in storage, and with marketing. If you can remember and write down the information afterwards, this is the best method. If there are facts and figures that you are not likely to remember, jotting down a few notes will not be seen as aggressive questioning. Do not ask the farmer, "Do you think that something or other is a problem?" Let the farmer do the talking and tell you what he believes are the problems. It is very easy to put ideas into someone's head and words into someone's mouth. The farmer may agree with you because he thinks that you should know what is right and what is the best solution. An extensionist has to be a good listener!

Once you understand the production system, you can then decide whether any of the cultural practices are wrong--based on the knowledge that you now have about the crop. Remember that the farmer may be doing something that you consider wrong because of economic and social reasons--not biological ones.

Diagnosis of limiting factors does not necessarily lead to identification of the solutions. The solutions may require inputs that are not available or are too costly. Solutions should be based, where possible, on modifications of existing technology or based on generation of new low-cost alternatives. Experience has shown that farmers easily adopt simple (single) changes but rarely complex technological packages designed to solve many production problems. It is best to take one step at a time.

Any ideas that you have about using different methods or materials to improve a crop have to be eventually tested and evaluated on-farm, through trials and demonstrations. These trials must be carried out by the farmer in the normal course of his farming operations. The farmer must understand what he is doing and why he is doing it. The motivation to cooperate in, for example, testing a new variety must be because he understands its potential for giving him better yields, and not because he is getting free seed and fertilizer to carry out the trial.

APPENDIX I

The farmer's evaluation of an alternative technology is as important as one based on agro-economic figures and calculations. His perceptions and opinions are essential, and should be sought whenever possible.

1.5.3 Poor Quality Seed Tubers

Seed potato stocks of poor health status are probably the most important factor limiting the yielding potential of the crop. Since there is no seed production scheme within the country, nor importations of good quality or certified seed tubers, the quality of the farmers' own planting material and that in the informal seed trade must be slowly deteriorating. Unfortunately, there is no information on aphid population dynamics or degeneration rates of potato stocks in the highland areas, where it is possible that farmers still have stocks with acceptably low levels of both leafroll and severe mosaic virus diseases. Twelve years ago it was possible to find crops of the local varieties in Bamiyan with low levels of virus infection, and this could still be the case today there and in other highland zones. Yields of over 20 t/ha (4 t/jerib) reported in 1988 and 1989 support this view.

Providing that no soil-borne diseases and pests such as bacterial wilt and the golden nematode have become established in these areas during the past decade, farmers will be able to improve the quality of their seed stocks by using the seed plot technique. This is based on the principle of selecting a limited number of healthy-looking plants from within a crop, storing the tubers from these selections separately, and using them the following season to plant a seed plot. This approach to seed stock improvement is not feasible at lower elevations where populations of the aphid *Myzus persicae* are high and virus spread is rapid, and where wilts caused by *Fusarium spp.* and *Verticillium albo-atrum* are known to be present.

1.5.4 Lack of Agricultural Inputs

Of all field crops, potato gives the best response to farmyard manure (FYM), and significant yield increases can be obtained with small amounts of artificial fertilizer. Where possible, farmers use FYM on their potato crop, but the reduction in numbers of farm animals as a result of the civil war will have greatly reduced the quantity of FYM. Few farmers have access to artificial fertilizer, and often do not have sufficient money to purchase the quantities needed to optimize yields, even when it is available. Urea, the only fertilizer manufactured in the country, is generally available, but phosphatic fertilizers are in very short supply. Farmers are reported not to be applying any fertilizer. The yield response to phosphate can be considerable, especially in soils low in phosphorous (P). This element contributes to early development of the crop and early tuberization, and is also reported to increase the number of tubers per plant. Productivity levels will continue to remain low if the crop does not receive sufficient phosphate.

APPENDIX II

ON-FARM TRIALS WITH VARIETY DIAMANT

Planting

The extension agent should be with the farmer at the time of preparing the cut seed tubers and at planting, but the farmer must be allowed to follow his normal practices. Even if he is cutting the tubers wrongly or too small, he should not be corrected as we are interested to know how **Diamant** compares with the farmer's variety under normal farming conditions. All cultural operations must be those that the farmer practices.

If the farmer applies farmyard manure (FYM), this should be applied to all the potato field including the plots in the trial. If the farmer applies any of his own artificial fertilizer, this should NOT be applied to the plot of **Diamant** NOR to the plot of the farmer's seed that is included in the trial.

Mark off two 500 m^2 plots and apply the fertilizer. Remember that only 1/4 of the urea should be applied with the DAP. The remainder will be applied at ridging. One plot will be planted with **Diamant** and the other with the farmer's own tubers.

Let the farmer plant the tubers and carry out all operations. If the cut tubers of **Diamant** are sufficient to plant more than the 500 m^2 plot, the extra tubers can be planted outside the plot.

If the tubers are not enough to plant the whole plot (say, only 400 m^2 or 450 m^2), make certain that the plot of the farmer's seed is exactly the same size. Remember that the amount of urea for the second application at ridging up is sufficient for 2 x 500 m^2 plots.

Another plot in the farmer's field that has only received the farmer's manure/fertilizer and not any AASSP/PSA fertilizer should be marked out. At harvest, this plot will give us an estimate of the yield that the farmer gets over all his field.

The three plots, of equal size, that will be harvested are:

1. **Diamant** that received AASSP/PSA fertilizer;

2. Farmer's variety that received AASSP/PSA fertilizer; and

3. Farmer's variety that received the same treatment as all the other parts of the farmer's potato crop.

List of Observations

1. Name of farmer
2. Location of farm
3. Number of jeribs of potatoes
4. Number of years that the farmer has grown this particular stock, i.e.. When did he last purchase seed tubers?
5. Name of variety
6. Storage method used if farmer's own seed
7. Physiological condition of seed at planting
8. Distance between rows and distance between plants in the rows
9. Size of the whole tubers/cut tuber pieces planted
10. Date of planting
11. Date of emergence (when approx 90% of plants emerged)
12. % emergence (Count a few sample rows and note number of missing plants. Calculate % emergence.)
13. Date of final ridging/second application of urea
14. Stem density when the plants are about 30-40 cm high (Count the number above-ground stems in 4 randomly selected rows, each of 10 m)
15. During the growing season, observations on crop growth and diseases (to compare the two varieties)

16. Dates when each of the two varieties are maturing (foliage turning yellow and plants beginning to die)

17. Date of harvest. (Each variety should be harvested when it is mature. This may mean that they are harvested at different times. The full potential of each variety must be achieved).

18. Total yield from each plot

19. Yield of marketable tubers from each plot

20. Storage method employed if not detailed in No.6 above

Frequency of irrigation may be noted, but this information is not important since the two varieties will receive the same treatment.

1.5.5 Losses in Storage

In the highlands, tubers not sold at harvest are kept in the dark in buildings until November and then stored in pits in the ground during the winter. This is the only method available to farmers in areas with extremely low temperatures. Losses of 15-20 percent have been reported when pits are opened in March or April when the tubers are beginning to sprout, but AASSP/PSA extensionists suggest that losses can reach 30% or more. This high level of loss could be reduced by more careful selection and handling of tubers when the pits are filled.

1.5.6 Poor Agronomic Practices

Experience has shown there are a number of other agronomic practices, that can contribute, individually or combined, to low productivity levels. The more important of these are:

- Seed tubers not at the correct physiological stage at the time of planting.
- Tubers cut into seed pieces that are too small, even though they contain two to three eyes.
- The seed pieces are planted immediately after they are cut, without allowing the cut surface to suberize or not treating the seed pieces with fungicide. Rotting of the seed pieces results in poor emergence.
- Competition from weeds and poor earthing up that does not provide plants with sufficient soil for optimal tuber formation.
- Inadequate irrigation, especially during crop establishment and from tuber initiation throughout the bulking period.

1.5.7 Diseases and Pests

AASSP/PSA extensionists say that blight is the most serious disease. This is assumed to be late blight caused by *Phytophthora infestans* and not early blight due to infection with *Alternaria solani*. If late blight is causing economic losses in the summer crop in the highland areas, where environmental conditions, such as temperature and humidity, favor the spread of the disease, farmers will have to spray with a fungicide such as Dithane M-45. Dithane M-45 is currently not

available in Afghanistan but, can be purchased in Pakistan. None of the European varieties grown in similar situations in nearby countries like Pakistan have a high enough level of field resistance to withstand the disease without spraying. Early blight, which needs warmer and drier weather than late blight to build up to epiphytotic levels, can occasionally be a problem in the plains and lower hill areas. Very rarely is it economic to spray against this disease. Of the other diseases that have been recorded in the country, only those caused by viruses are of widespread importance and cause economic losses nationwide. The others include stem rot and black scurf (*Rhizoctonia solani*), Verticillium wilt, Fusarium wilt, and pink rot (*Corynebacterium sepedonicum*). Potentially dangerous diseases known to occur in neighboring countries include powdery scab (*Spongospora subterranea*) and bacterial wilt (*Pseudomonas solanacearum*). Control or partial control of these diseases that are also soil-borne can be achieved by using clean seed and following a good rotation pattern where potatoes are not grown consecutively in the same field. However, the latter two organisms can infest soils for many years and are very difficult to control.

The two most important insect pests are aphids and cutworms. Certain species of aphids are important vectors of virus diseases but do not directly damage the crop. They cannot be controlled by spraying. Cutworms can be locally troublesome, but can easily be controlled by soil application of a proprietary insecticide such as Carboturn (furodon 3 b) which is available in Pakistan.

1.5.8 Marketing Problems

Even under normal conditions in peacetime, the marketing of perishable vegetable crops presents serious problems to farmers. The difficulties that farmers must face in Afghanistan today are therefore multiplied. Export to Pakistan and the long distance trucking of potatoes from the major growing areas to the large urban centers in that country is badly curtailed or even, in some cases, impossible. In many countries of the torrid zone, marketing is always listed by potato growers as their most important constraint to profitability. Afghanistan is no exception. The internal trouble over recent years has affected those farmers, especially in provinces like Bamiyan, who grow potatoes as an important cash crop. Farmers in the lowland areas, where the crop is harvested in May/June, could profit from cold storage facilities, but the spring crop is small compared with the main summer crop, and cold storage might not be profitable. Commercialization will always remain a problem area.

II. STRATEGY FOR POTATO IMPROVEMENT

2.1 Introduction

While potato is grown in many provinces, most production comes from those areas of higher elevations. Many farmers have small areas, from less than one jerib to one or two jeribs. Potato is regarded as the most important vegetable in some provinces, where it is grown by large numbers of farmers. In times of war and food shortages, potato has been an important vegetable. Tubers contain between 75% and 80% water, but they also have 18-20% carbohydrate and about 2% protein, vitamins and minerals.

At this time, in areas where potatoes can be grown and where there is a need for more food, many more families should be encouraged to plant small plots of potato to feed the household. The tubers can be kept for many months, except in areas where temperatures are very high immediately after harvest and storage may be limited to a few weeks.

Seed tuber quality, storage, disease control, and crop agronomy need immediate attention. All these aspects can be relatively easy to target through:

- Improving the quality of farmers' own seed tubers through on-farm selection (seed plot technique);

- Importing and testing one or two white-skinned varieties that should outyield crops of the local varieties grown from farmers' own seed or seed bought in the local market;

- Improving storage and field agronomy through training extension workers in these technologies; and

- Preparing extension bulletins, leaflets and silk screens for farmers in Farsi and Pushto on different subjects relating to potato cultivation and on-farm seed production methods.

2.2 Improving Seed Tuber Quality: The Seed Plot Technique

Farmers in Afghanistan cannot buy certified or improved seed potatoes because there is no seed scheme within the country and there is no importation of seed tubers.

Those farmers who grow potatoes at low elevations are unable to keep tubers from one planting season to the next. They must purchase seed tubers in the local

market or from another province where the crop is grown at higher elevations and stored. In the highland areas some farmers will have poor crops with a high percentage of virus and other diseases that are transmitted in the tubers. With these types of crops it is very difficult, but not impossible, for farmers to improve the health status of their stocks. When crops contain a reasonable percentage of healthy-looking plants, it is very easy to improve the quality of the seed tubers that farmers save for their crop next year.

The principle behind the method is one of positive selection, i.e., the selection of healthy-looking plants to provide tubers for the following seed crop. The method is known as the **seed plot technique.**

Procedure

The size of the farmer's selection program depends on the number of jeribs that he usually grows. The program includes the following steps:

a) If the farmer has more than one field of potatoes, he decides on the best field in which to make his selections.

b) Selection should be made when the plants almost touch each other and can still be recognized as individual plants. If the crop is a mixture of two or more varieties, selection should be made at flowering time when varietal differences are more easily recognizable. Mark the best, healthy-looking and most vigorous plants in the field with stakes. Stake all plants needed at the same time. Stake only plants of the same variety to avoid mixtures. Stake more plants than are actually needed to plant the seed plot the following year.

c) Check the staked plants during the remainder of the growing season and remove stakes from any that develop virus symptoms or look unhealthy (e.g., wilting). Plants with foliar diseases such as early or late blight should still be selected. Mark the best and most vigorous plants in the field with stakes. (From Bryan, J.E., 1981, *On-farm seed improvement by potato seed plot technique*. Technical Information Bulletin 7, International Potato Center, Lima, Peru.

d) Harvest the staked plants and remove the tubers from the field before harvesting the rest of the crop. This will avoid tubers from other plants getting mixed with those from the selected plants. During harvest eliminate plants with poor yields, tuber-borne diseases or deformities.

POTATO PRODUCTION

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THE PRESENT SITUATION, STRATEGY FOR IMPROVEMENT

AND PRODUCTION INFORMATION

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Prepared By:

Garry Robertson, Consultant
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